first two steps, the recognition and the evaluation.

First of all, we recognize the exposures. We take into account time factors. We take into account exposure data. We take into account factors such as dilution, distance from the process. We take into account the percent of asbestos in the product.

For the case study I am going to talk about this morning, typical exposure factors that I used, and it would vary on a situation, obviously, but if you make these exposure factors wide enough, essentially you can make them wide enough to give yourself some degree of confidence.

If you are covering a factor to take into account the fact that you are not doing the work yourself but you are in the immediate area, if you let the factor go from 1 to 30 percent, you know, you probably covered it unless you are working elbow to elbow, or unless you are, you know, several hundred yards away or several hundred feet away.

Time your other trades. That is going to be very case specific. But, in the case I am talking about today, 2 to 50 percent seemed to cover it.

Difference between the indoors and the outdoors may be a factor of between 2 and 20. The percent asbestos in the product from what I have seen

is generally -- has a linear dependence on what gets into the air, all other factors being equal.

Exposure factors can have somewhat narrower and alternate range values with specific information, but oftentimes I wind up working with ranges like this or some modification of this.

This is a tracer gas study that I did to try to further take a look at the so-called bystander factor, that is the factor that would be in the workplace surrounding an individual involved in an asbestos exposure. Used sulfur hexafluoride as a tracer gas, and you can see that under very stagnant conditions indoors, the surrounding environment, by the time you get 25 feet away, is down to 1 or 2 percent of the continual release occurring.

We tried to simulate somebody scraping asbestos, and we had a continual release as we moved the hand back and forth, and we had monitoring points set up in this building as indicated by the various dots.

On the other hand if we have some directed wind, indoor wind in this case -- and this was just a different ventilation condition, different setup in the building by turning on and off various ventilation systems, you can see that the down wind

values, when you get about 10 feet away, are about half of the primary exposure. When you get 35 feet away, it can be 20 percent. When you get to be 75, 85 feet away, it can be something like 10 to 15 percent.

On the other hand, the upwind concentrations are zero, and to the sides are zero, so on the average you are still talking about, oh, 10 percent or so, or less in the same general work space.

This has to be tempered by the fact that if you are in a confined area you can have dust buildup in the room, for example, on board ships in other confined areas, and if you had a very vigorous process, you simply can fill the space with fibers and, therefore, we have to be conservative when interpreting this data and that is why I use a wider bystander exposure factor when I actually do these estimations.

I want to get into the case history. This was a pipefitter/plumber, he was born in 1933. He developed lung cancer in 1999 at the age of 65. He had some pleural plaques. He had a low degree of interstitial fibrosis. He smoked from 1950 until 1979. He didn't smoke any Kent micronite filters

with crocidolite.

He was questioned in detail in nine depositions and in trial testimony about his work history. Coworker depositions were available also.

He worked as a pipefitter/plumber mostly in larger urban commercial sites, 85 to 90 percent new construction. What is the significance of that? Well, if he is in new construction, he is not removing pipe covering to any appreciable extent, except in some instances tying in to existing systems when he is building a new building as part of a complex.

He was a hands-on apprentice when he started. He became a mechanic. He worked his way up becoming a foreman, a site superintendent. His primary exposures lasted until about 1975 to 1980, around 20 to 25 years of exposure.

There was information on 45 sites evaluated through 1980. He had limited hands-on asbestos disturbance. He was in the vicinity of pipe insulation, fireproofing, and gaskets and had some hands-on associated with these types of material himself.

He installed asbestos cement piping using non-power tools. He reported working frequently side

by side with asbestos pipe insulators; however, it was often fiberglass materials. He reported working in the vicinity of tapers and sanders, spray application of fireproofing and joint compound mixing and sanding.

I want to talk about the application of the Monte Carlo simulation on this case history briefly. Basically what Monte Carlo is, it allows you to take several distributions, in this case there you see the distribution for exposures associated with dry mixing, you see the distribution associated with sanding, for application for cleanup.

The Monte Carlo technique allows a random number generator to generate values in association with those distributions, and the process is repeated, for example, 20,000 times. Equations are set up to combine those exposures, taking into account the percentage time for each of those dry mixing, sanding, application, cleanup, and those percentage times can be put in as a range as well, and then taking into account the fact that some of the time the taper/sander is just applying or not being exposed, or you could take -- if the taper/sander also puts up sheetrock, you could essentially have a zero exposure for that activity.

The whole idea is the Monte Carlo method allows you to combine these various distributions into an overall distribution that you see on the bottom of that chart, which would be indicative of a typical or average time-weighted average for an eight-hour day, assuming those distributions.

And you can see for the taper/sander a 1-to-5 fiber per cc range is useful with a central tendency around 3 fibers per cc.

The assumptions that I used for the case history were wider than I usually use in this example because I wanted to be inclusive of additional IH viewpoints. This happened to be involved in litigation, and the Plaintiff's industrial hygienist had higher ranges than what I usually use, and so I said okay, let's not argue about this, let's just make the ranges wide.

I also use wider than -- wider exposure factor ranges for bystanders, et cetera, than what I think is necessary, but I wanted to be inclusive. And basically this is an illustration of a what-if scenario, what if the exposures are this high. What if the exposure factors are in this range. Or you can use the technique to come up with a best estimate.

And so it is very careful to find what you are up to in the begin so that you can probably interpret what the results mean.

I want to show you with 40 different exposure events or potential exposure events, 45, whatever it was. I can't show you all of the assumptions that went into this, but I want to show you a few just to give you a feeling for it.

For the duration, this is one of the exposure events. We had a four to seven month. He couldn't remember precisely, so he put in a range, and we made the probability the same, represented by that green rectangle.

For the percent time exposed, as a bystander to insulation work, he had some descriptors that he used in words but didn't have an exact number. So we came up with a reasonable range of 10 to 50 percent, a factor of 5. For a bystander factor, sometimes he was right in the same room, right next to them, and other times he was at some distance. Again, we could have let this go essentially 0 to 50 percent, but it doesn't change the result much, so we just let it go at 10 percent to 50 percent.

The primary worker exposure, if you look

at the Cooper Balzer study for general commercial sites, you get about an average of 3 fibers per cc in the 1960s; on the other hand, there are alternative studies out there, but we allowed the highest part of the distribution to be a 3 fibers per cc, but we allowed the range to go from 1 to 43 fibers per cc using the triangular probability distribution that you see at the bottom of the page there. Or bottom of the slide.

Similarly for sheetrock tapers and sanders, when he was in their presence, we use the same time range. His words indicated a little less time of exposure, so we used a range of 5 to 25 percent. We used a 10 to 50 percent bystander factor. Probably too high. But again, we wanted to be inclusive. And instead of the essentially 1 to 5 fiber per cc range that I showed you, we extended it from .25 to 10 for the central with the highest part of that at 3.

Similar for people, labor sweeping up, you can see the data there. Removal of asbestos and pipe/block insulation, sometimes he would do tie-in work. In this case he did it for two days. Percent time exposed during the day seemed to be about 5 to 10 percent.

He worked hands on with somebody else doing this. Sometimes he did it and sometimes his partner did it, so we used a bystander factor there of 50 to 100 percent.

And for the primary worker exposure, there can be a great deal of variability when you are removing asbestos. Again using Cooper Balzer as the most probable, we took 8, but we allowed the exposure range to go from 1 to 97.

Scraping of fireproofing, Paik has an article where he puts things in terms of geometric means and geometric standard deviations, and he has done this for essentially the eight-hour workday rather than the short-term event. And you can see what that distribution looks like graphically at the bottom there, it ranges from about .05 to 2 fibers per cc on a time-weighted average basis.

But essentially you can input into the Monte Carlo, you know, a formula, a geometric mean, a geometric standard deviation. You can input triangular distributions or even probability distributions as suggested by those rectangles.

So how did it turn out? Even using the broad exposure ranges, when you make a lot of little slices, you get a range that looks like this. And it

is really not as broad as you might think, considering the broadness of some of the assumptions that go into doing it. You can see the 95 percent confidence interval. It is in blue. 2 and a half percent of the data on each side of the distribution is in red. And so 95 percent of the simulated data points occur in the center as represented by the blue lines.

We have roughly a factor of three between the low and the high. We do the 95 percent confidence interval.

How can the use of such wide input ranges provide such a, I think, tight range. I think a factor of three. I almost tried to make the ranges wider so that the final result is broader. It is almost embarrassingly too tight.

But what I found is that the use of many exposure events per assessment, in essence, slicing up the pie into many events effectively increases end. It is the best analogy I can give you to try to explain this, which reduces the standard deviation of the mean total dose result.

Another factor is that many of the exposure events do not significantly contribute to the total dose, and that is almost the antithesis of

that first point, but one can determine what is doing what by running a sensitivity analysis on the Monte Carlo.

I think the basic idea here is that if you have a lot of data, you are taking a mean, the standard deviation of the mean gets reduced by the square root of the number, measurements that go into the mean or the so-called standard error concept.

To compare it, sometimes it is useful to compare a one dose with another. For example, in the previous talk there was the comparison of the gaskets with the pipe insulation.

To cover the range of possibilities and to complete the uncertainty analysis, we need to essentially divide one range of values by another range of values. The Monte Carlo technique is one method to perform this type of analysis.

In this example, one of our clients, which I will fictitiously call Acme, we came up with a range for his products, he was actually a boiler manufacturer, and you see the range up there. You know, it is a very trivial exposure, it is down in the background range, but it varied from close to zero to about 005 or 006 fiber per cc years.

If we want to know what percentage or what

fraction of a lifetime exposure that represents, we essentially have to divide that by the total lifetime asbestos exposure. And the Monte Carlo technique allows us to do that. What we can do is take the Acme-related exposure, divide it by the lifetime exposure, and come up with a ratio-to-lifetime asbestos exposure, which you can see is running from essentially 0 to about 7 parts in 10,000.

Uncertainty analysis is a very important part of any kind of exposure assessment or risk assessment. Wonder if they ask themselves does the exposure assessment make sense. We can do comparisons to other types of workers. For example, for this pipefitter, if I started getting results that were indicative of insulators I would say well, it probably isn't making sense.

You can make simplified estimations. Instead of cutting the pie into many pieces, you can try to get a sense for the frequency, for the various activities over a lifetime and come up with simplified estimations, and you better get the same results.

Is it consistent with what the literature says about the occupation. There are some estimations of pipefitters in the literature relative

to disease rates compared with insulators. And this has been primarily for shipboard work. But that can be viewed as a worst case.

There is a difference between variability and accuracy. Even though I showed you the variability, that variability is simply the variability associated with the assumptions that I made. It is not the variability from one person doing the exposure assessment to another person doing the exposure assessment.

And it shows variability, but the accuracy of the analysis is only as good as my assumptions, and so it is important to not think of the variability that one determines as a full uncertainty analysis. One is to think about both variability and accuracy issues.

So it is important not to overstate the utility of the confidence interval range that you determine by this method, and at the same time it is very useful, and I don't think it should be understated either.

How good is it from an accuracy standpoint. What I have done is before I started doing Monte Carlo, I essentially do a minimum kind of a mid range and a maximum. And where I had asbestos

body per gram information from pathologists, I tried to correlate the two, and of course the problem is that chrysotile exposures, the chrysotile fibers don't persist in the lungs, the amosite fibers do, and on top of that, all of us make asbestos bodies at different rates, individual to individual. Nevertheless, if you take the regression line through the data, ignoring those two green points because those are not my data, that was some other data.

(This concludes tape 1. Please go on to Tape 2 for the continuation of this program.)

SPEAKER: Code number AIHce 02/Forum 244, Part 2.

JIM RASMUSON: -- lines going from high to low. And I think it does illustrate the utility of working with ranges when coming up with this type of work. Does that indicate accuracy? No, it indicates correlation.

This is an example of retrospective exposure assessments that I have done for dioxin, and it didn't look this good until we averaged the results from two different laboratories. The risk of cancer from TCDD is using the retrospective exposure assessment, primarily looking at the dermal absorption pathway and taking into account body

weight, the sort of things you do for the EPA risk assessment.

But is it accurate? There is variability. The answer is well, it is accurate to a degree, but when we look at -- when we determine the half life of the decay of the dioxin in the body, we come up with a three-year half life for this, and CDC has done this on many more people and has come up with a seven-year half life.

And so while we have tremendously good correlation, except for one data point here, it isn't perfectly accurate. And so one has to think about precision, variability, accuracy in order to put your data into perspective.

These are not single-valued estimations, and one has to try to continually get at the idea of what is my variability, what is my accuracy, how well would my results compare with another industrial hygienist doing the same type of work.

One of the interesting things that is becoming more and more important is the difference in fiber type. There is good workers on both sides of this issue. Some would think that chrysotile is very potent for mesothelioma. Many of the epidemiological studies do not support this. And one possible

utility for the Monte Carlo analysis that I have talked about is to do a fiber type analysis within an exposure assessment, come up with dose percentage of exposure.

In addition, the technique is useful for specific situations, accidental releases. I have used it relative to risk communication situations involved with maintenance workers, that sort of thing.

Thank you very much.

(Applause.)

FRED BOELTER: Thank you, Dr. Rasmuson. The next speaker is Dr. Bill Dyson.

BILL DYSON: Well good morning. I have been sitting about as long as you have and it felt good to me to stand up, and so I thought you might want to stand up for just a second. Stretch a little bit.

I will continue to talk while you are stretch, though, to tell you why I have chosen this topic, which is just a little bit of an extension beyond exposure reconstruction, and that is to talk about mesothelioma cases.

What is at risk in this country today is very simple to calculate. There are around one per

hundred thousand cases of mesothelioma is the rate, and so that means that we have somewhere between 2500 and 3,000 cases occurring each year within the country. These are -- what is at stake for each of those cases is somewhere between 2 million and $10 million, so if you multiply that out, and assume that, say, 50 percent of them, or 40 percent, even, are going to come to a legal setting where the claim is that it is due to asbestos exposure, you are talking about an industry somewhere between 2 and 12 billion dollars a year. So there is a great deal at risk in talking about this.

Sorry, I have got to go back. And I don't know how to go back. Okay, back where I should be.

What I want to talk about here is attributable risk based on going a bit beyond just the simple calculation of exposure dose. This is applicable to mesothelioma. It is not -- it is certainly not applicable to lung cancer or to asbestosis from asbestos exposure.

The objective is to attribute the risk to individual exposure sources and determine the relative contribution of each of those sources to the total risk that the individual might have.

Obviously if the mesothelioma is an

asbestos-related disease, then the total risk necessary to cause the disease is the sum of the individual risk attributable to those sources. And the relative contribution is the ratio of the risk from the individual sources to the total risk.

I only pushed it once.

The first cut at this is a risk assessment based on exposure dose, and the equation or the proportionality that we would use here is that it is proportionate to the exposure intensity and the duration of exposures. You have heard that several times this morning.

This model for epidemiology does not fit the data; however, if you use it, and it is necessary to do this in each and every case, you can look and see if the lowest cumulative doses at which mesothelioma has been associated with asbestos exposure, is reached. And in my estimation, in epidemiological studies, that is somewhere in the range of 1 to 5 fiber years per cc.

I am going to try. There we go.

The particular example that I would like to use here is the case of an individual who early in his life was in the Navy. He came out and essentially became a carpenter's apprentice and then

worked his lifetime as a carpenter.

The individual sources of exposure here were 5 in his history, that was he worked as a boiler tender between the years of 1944 and 1946. For a period of time between 1960 and '61 he was cutting some asbestos cement board in building a cooling tower. He also used vermiculite to mix with plaster over the period of 1955 to 1961. It is a similar exposure but cutting shingles, asbestos cement shingles between 1950 and 1960, and then finally the exposure that he might have had as a result of drywall construction.

Dr. Rasmuson gave you the data on exposure from Monte Carlo analysis for drywall tapers, and you will see how I use similar data to that.

Doing just the exposure dose calculation in this case, the Navy, and I do it on a worst case scenario basis and do it in a fairly simplistic fashion because I find that I can explain it better to juries if I can get it down almost to sound bites and small categories like this.

But, the Navy exposure I attributed a .1 fiber per cc over a 2-year period for a total dose of .2 fiber years per cc. And in going on down, you see the various attributions here. But, particularly the

drywall exposure I use the upper end of the range on that, again, for a worst case scenario of 10 fibers per cc. He did it in 50 homes, 5 hours per home, so his total cumulative exposure here was about two-and-a-half fiber years per cc.

The largest contribution of which, just based on an exposure dose analysis, is the drywall application. Now, what I would conclude from this, of course, if I stopped here, is that he did have sufficient exposure or sufficient minimum exposure for the mesothelioma to be asbestos related, and if I looked at it just on the basis of exposure dose alone, I would attribute a good portion of his -- the attributable risk here to the drywall installation.

But let's take a further refinement of this model. And that is a risk assessment based on latency. This is commonly called the Peto analysis in the world of asbestos litigation, at least.

It was -- the mathematics of it were shown in a paper by Morgan in around 1988 that he tongue in cheek called who done it, or assessing liability in asbestos litigation. And what this says is is that the risk is proportionate to the period between when the diagnosis for mesothelioma occurred and the initial exposure for that particular individual to

asbestos raised it somewhere in the range of the third to the fourth power.

In applying this, we used three for chrysotile exposures, four for amphibole exposures, or some people used just an average of 3.5 for mixed exposures. This acknowledges what we have seen in the epidemiological literature that early exposures contribute more to the risk of mesothelioma.

If we applied this to the case of the individual in this case, the relative risk, just based on those latencies from the diagnosis of mesothelioma in the year 2000 and the early exposure periods in the Navy and drywall and so forth, again the relative risk looks like the drywall exposure's the biggest contributor to this individual's risk of mesothelioma.

The others, again, based on the wide time frames and so forth for the asbestos cement siding on the house, gives a large relative risk as well.

But then we take it a step further. This is a risk assessment model that was used, it was proposed initially by Dr. Nicholson, it was used by OSHA in their risk assessment for asbestos to determine the permissible exposure limit, and what this says is that the absolute risk of mesothelioma

is proportionate to the exposure intensity as well as the latency raised to the third power.

There are few refinements of this, of course. Some people say that the minimum latency is 10 years, so you need to subtract 10 from the latency that is calculated here.

But for the few epidemiological studies that we have that show a dose response relationship for mesothelioma, the proportionality factor here has been estimated about 10 to the minus 8.

So again, taking this same example and applying it to the individual that we have used before, the slight difference and nuance of this in this application is that you will notice that the intensity numbers that I am using here are different.

They are not different for the Navy because that was a fairly continuous exposure, but in the case of the cutting of the asbestos cement board here and here, what I used was the dose, the total dose that I calculated, divided by the number of years. In this case it was .4 fiber years per cc, but it is divided by only one year, so that is the average exposure intensity in fibers per cc. Here you are dividing it over a 10-year period the same dose, but it is -- the intensity average and

intensity over that period of time is lower.

This is necessary to do because the -- if you don't, the numbers get skewed on this. And again, note where I used a 10 for the intensity for the few months or the 50 homes that he did drywall work in, if you attributed over that entire duration, the average intensity over that duration is 0.7.

So now we begin to see a slight shift in the relative risk of mesothelioma using this particular model. Now the drywall element of this exposure goes down as a relative contributor, and the Navy portion of it goes up somewhat.

The next refinement of this model, Dr. Rasmuson mentioned that we have interesting information about the potency of various fiber types to cause mesothelioma. I don't think that there is any doubt in anyone's mind that there is a different potency or certain variability by fiber type.

The best estimate that we have from this comes from a fairly recent article of Hodgson and Darrington, and they say that the relative potency by fiber type between the fibers ranges from 1 to 100 between chrysotile and amosite -- they didn't mention tremolite, but it is in the same category -- and 1 to 500 between chrysotile and crocidolite.

So using this information we can refine our model somewhat further. And in this case now, say that the risk of mesothelioma is proportionate to not only the exposure intensity and the latency cubed, but also the potency of the fiber type involved.

Applying that particular model, the chart becomes larger, the numbers become smaller, and I apologize to those of you in the back of the room, hopefully you can read some of it, at least.

We have an interesting situation because of the fiber types. Most of the fibers here in the cutting of asbestos cement board, and in the drywall we are talking about chrysotile where we attribute a potency of one.

On the other hand, in the Navy we have a mixed exposure with amosite, and the vermiculite exposure is to tremolite where we would put an exposure potency of a hundred.

When you run the calculations using this particular risk model, things change very dramatically, the two contributors, the two largest contributors in terms of risk to this individual's mesothelioma were the Navy exposure out here, and the vermiculite exposure that he had.

Primarily as you can see it is due to latency and potency as opposed to the intensity element of it. Based on this, I conclude, at least, that exposure dose estimates alone are not sufficient for attributing risk and doing relative risk attribution in mesothelioma cases. As they are, it is sufficient in lung cancer and asbestosis cases. The latency and potency of the fiber type are very, very critical factors and oftentimes the most critical factors.

And then finally it is my opinion that all factors must be considered in the risk assessment for mesothelioma cases to get an adequate idea of the relative contribution of the individual components of the exposure.

Thank you so much.

(Applause.)

FRED BOELTER: I am going to talk about two cases, one involves a historical exposure assessment similar to the previous speakers where we are looking back in time using information gleaned from interviews as well as depositions or studies, and ultimately calculating a total lifetime dose.

Another study I am going to share is more contemporary experience where it is not unusual that

asbestos is in buildings today, and people encounter it accidentally. And I will show how to use the same concept of dose reconstruction to determine a dose associated with that to communicate the significance of the exposure and the risk associated with it.

What we have developed is software to be able to look at a dose reconstruction. It is built on the principles that all the other speakers have discussed; namely, the establishment of exposure events and the building of a timeline.

What is shown here is a small portion of the discrete events. Each line is called an exposure event, and it has a start date and a stop date and thus a total number of days. For a default value in determining the number of equivalent years between a start and a stop date on a calendar is 250 days. So 250 work days per year equals one year for the purposes of doing a fiber year calculation when looking at an occupational experience.

So what we do is in looking at the person's work history, develop this timeline; namely, what was their first employment or engagement with asbestos, through to their most recent or last one.

Each timeline is either defined by the period of time that the person was employed for a

particular employer, or it is defined by specific activities that are performed at that employer. So this summary table is the employment periods.

For each exposure event, therefore, each line that I showed on the previous chart, is an exposure event form. This will contain the name of the employer, the location. In this particular case, it was a deposition source. So the location specifically in the deposition where that information was contained, where the employer was located, information related to the activities, and the nature of the activities, in this case, the renovation of homes, where those were located. And then the individual activities that were performed for this exposure event, therefore -- or the activity was the working on renovating homes, but there were a series of different specific activities that could have an exposure associated with them while doing this work, such as cutting through flooring, pulling cable, cleaning up, removing insulation, cutting through the ceiling. Each of these are specific activities that have to do with this exposure event.

What we also have is links to literature so that there is a basis for each entry in the process of building this timeline. For each of those

activities that I showed on the previous chart, there is going to be a specific activity information summary.

The information, for example, cutting through the floor, there will be a description of what that activity involved. There is an attribution to a particular type of manufacturer material or specific manufacturer. There will be information entered, if it is known, about the composition of the material in terms of the fiber type. The general categories are amosite, crocidolite and chrysotile, as the previous -- several speakers discussed the potency differences between these fiber types.

There is also information entered about the proximity, whether the person performed the work, whether they were near the work, or whether they were around the work as the concentrations will vary depending upon the proximity.

And then we begin the process of estimating the amount of time during the day. The individual might say well, you know, it was somewhere between 5 and 15 percent of the day, or there might be some other type of information that we will utilize to come up with a time estimate, realizing the exposure event was an annual experience. Looking

at the activities, it is a daily experience.

So during the day there is some portion of the day that is directed toward this activity that was described as cutting the hole through the floor. It is clearly not an all-day activity, some portion of the day. So that information would be entered here.

The frequency is going to be the number of hours per day, not in terms of the percent of the day, but whether it was an eight-hour workday, a twelve-hour workday, a ten-hour workday, we need to adjust the equivalent number of years that that would represent, and thus adjust accordingly the number of fiber years calculations.

There might be information about the frequency per week, it might be five days a week, it might be only one day a week. It might be once every two weeks, in which case the time that would be entered would be .5.

Then we are going to estimate the eight-hour time-weighted average if the person were to have performed the job all day long, as if it were an eight-hour time-weighted average. That will then be adjusted based on the percent of the day that the person actually performed the work.

If there is information on the attribution of a specific material, realizing there are a number of manufacturers of the same type of product, if there was a specific interest in looking at a manufacturer's material, we can enter the percent of use that that particular manufacturer represented.

We do this for each activity. Each activity for each event. So, this process is a cumulative one.

We have links to a library of data sources that allow as a basis for either the estimates of time, the estimates of concentration, the duration of the activity, the content of the material. So at each step in the process, if there is a linkable reference, we can link to it.

By then clicking on that particular reference, we can call it up out of the database. We have approximately 1200 specific references in our database.

When we then go back to looking at the event summary, we have the individual activities with the event, and we can take a look at the effective mean dose associated with this specific event. Along the way it is calculating and recalculating the dose as the information is updated.

This total dose is then reflected on the first sheet that I had shown you, which are the individual line items, and there are many of them, which are -- each are called an exposure event, which when added together form a cumulative dose that we call an effective median dose, in this case, it is about 24 fiber years for this individual's total dose.

We also can perform a Monte Carlo analysis on this accumulation of information. It is analyzing the variability associated with time, variability associated with concentration, variability associated with the estimates that are being used in this reconciled reconstruction of a person's work history.

The output of the Monte Carlo analysis, as Dr. Rasmuson spoke, is a probability distribution with a mean in this particular case of about 27 fiber years. So 95 percent confidence -- 90 percent confidence, the range for this individual was between 24 and 29, almost 30 fiber years for a cumulative lifetime dose. And this is built on the systematic slicing up of the information into component parts where we can provide estimates of time and exposure through concentration.

There is also an output from the analysis

to look at the statistics of the inputs and outputs as well as a sensitivity analysis on which of the particular inputs had the greatest variability associated with them and thus would influence the results most significantly.

So not only do we get an output in terms of a range, we also get an analysis on which particular input variables effect the output the most significantly. And this is that sensitivity analysis; and it says in this particular case, it says that this particular activity, which you can go back to the chart, was the highest ranked as having the greatest influence on the results.

As a result of having this, you can go back to see whether you can refine the results or refine the input more carefully, or whether it just happens to be the activity for which we have the least amount of information.

There are various outputs then that would be produced in terms of a report. This is a summary of the references that were used in compiling the basis for the ultimate dose calculation.

A dose analysis summary, which looks at the individual's work history in terms of chronological time, this being the oldest exposure,

this being the most recent exposure, and looking at the time period during which the greatest exposures occurred, and looking at the significance of the exposure in terms of the height of the bar.

We also have an event and activity summary output. So for each of those line item entries is a generation of report which looks at the individual activities and the inputs associated with that, as well as the specifically cited sources.

And then finally we have a reconstruction summary output that looks at the significance of a particular exposure with respect to a product as well as the manufacturer. So through this process we can systematically compile a person's timeline, develop a work history through event, exposure event compilations, and output that information in terms of product type, period of time, or activity that was performed on those individual products.

Well, that is a historic reconstruction. Let's talk about one that is a more contemporary one. In this particular case, an individual was putting in a fire annunciator system and didn't realize that the acoustical plaster that was on the ceiling was asbestos-containing. What the individual did was drill holes through the ceiling accidentally, and the

activity occurred for some period of time, and once it was discovered it was stopped, but nevertheless, the individual was very concerned in wanting to know when they were going to develop cancer as a result of having been exposed.

Now as industrial hygienists, intuitively we know how to answer that question, but the objective here was to put some science and mathematics behind determining what the dose was of the event.

And we can use the same process to be able to do that. We look at the construction incident as an exposure event. So this incident is the exposure event. It was composed of specific activities, in this case cutting through the ceiling. It was an activity that through interview was determined to have taken a specific amount of time. However, there was a range associated with the time. Well, I think it was at least this long and I don't think it was any longer than this. That defined the range of the time.

The acoustical plaster was able to be sampled, it actually was inventoried as part of the building record, and so we knew what the material was composed of. We were able to compile then an

activity description of drilling the three-quarter inch holes into the ceiling. We knew what the -- we knew it was a 15 percent chrysotile material. We knew that the person was working with the material. We knew that it took somewhere between 3 and 12 percent of the day, an 8-hour day, 5 days a week, except it was 1 day that this activity occurred.

We referenced back to a specific article since we weren't there to measure it. This is the article that was referenced. Having to do with a sprayed material, it seemed to be the closest fit to the description of the activity. And here is the link to that specific article.

The calculated dose then from drilling a hole through the ceiling for the period of time that it was described to have taken was a minimum dose of .000002 fiber years.

With that -- when we go back to the first page where that is shown, it is too small to be able to be shown in the effective dose, but we were able to do a Monte Carlo analysis on that and demonstrate that based on the inputs, these variable inputs, that the range was between about 6 and 17 to the minus 6 fiber years of dose associated with that specific event.

This is helpful in being able to communicate the significance of the event. Clearly it is not something we want people doing from a preventative standpoint, but when these occur, and they do occur, there is a mechanism to be able to reconstruct that event and communicate effectively with the individual about the significance of the event. We can do a similar summary on that as well as a detailed statistical analysis and a sensitivity analysis as well to determine whether it is a close fit.

With that, I would like to thank all of you for your participation. We have some time for questions and answers. And I appreciate all of you showing up on the morning to participate in this experience.

Are there any questions?

Yes.

MORTON CORN: Would you entertain a comment?

FRED BOELTER: Please, Dr. Corn.

MORTON CORN: I am Morton Corn, Professor Emeritus Johns Hopkins University.

I think there is a very important philosophical component to discussing these

techniques, and I would like to briefly elaborate on that.

Retrospective exposure assessment had its roots in epidemiologic studies, and I was privileged to be involved in many of those early ones, where we worked with a cohort of workers to address the question, is there a dose response curve, and these studies involved 18,000 workers, 5,000 workers.

We had anchor points for exposure with time in the same facilities, and the challenge was to fill in the missing years and the missing exposures which could be correlated with technological change usually, and that became known as the job exposure matrix and retrospective exposure assessment. And the techniques were extraordinarily useful because they did, indeed, focus on some thresholds where disease was recognized by the epidemiologist. We did have to pool our data into classes to correlate, very low exposure, low exposure, medium, high. The data were not usually good enough for the individual correlation.

What we have been talking about today is not that. And I think that is science and is judged as science. We have been listening to that technique reversed in response to the legal arena. We have

been asked to take retrospective exposure for an individual, not for a cohort, and to use the techniques developed for a cohort to answer questions in the legal arena in the dispensing of justice. And those questions are to be answered with a more likely than not, or a high degree of scientific uncertainty to the individual performing the exposure analysis. And the question is usually, since the -- in the asbestos arena, the cohort studies have given us, I believe, a threshold for fibrosis, and a threshold for lung cancer, and a suggested threshold for mesothelioma. We are being asked was the exposure consistent with those guidelines, do we believe the exposure could cause the disease, because there is a lot of argument about what fibrosis is, and there is a lot of argument if the lung cancer is due to smoking or to asbestos. So the first question is, was the threshold passed.

Second question we are being asked with the presentations given this morning is what is the assignment of damages, assuming that the disease is the manifestation of the totality of exposure.

In doing that, and I think we have heard some very good utilizations of the exposure assessment methodology, but I think we should be

aware that not only is this a science and an art, I think it is an art and a science. We have drawn on some of the science to persuade juries or judges of the answers to those two questions.

We are using data for individuals not in those places where they worked. We all know the variability of the workplace. We have heard some point estimates which I think we just cannot give. The variability is essential to the data we assume, and it is even greater when you realize that data is not for the establishments for the individuals involved.

So uncertainty is absolutely critical in all of this for the integrity of the presentation.

I believe some of the methodologies given have the capacity to fool us with the specificities and the readouts of the computer. Bill, for instance, is drawing on assumptions that are hot arguments. Fiber type is still not accepted, Bill. And while I would agree with you, you have got a big persuasion argument with the assignment of factors.

Peto's time analysis is still not totally accepted.

The bottom line for what I am saying is, we are going to be faced in the courtroom with one of

us on one side and one of us on the other side presenting these arguments one to the pleasure of the Plaintiff and one to the pleasure of the defense, and the stakes are not only individual credibility but the credibility of our field. Do not oversell these methods.

I think the progress I listened to here today was superb and I think some of it was literally the state of the art of doing this. But as the practitioners, we should recognize just how soft much of it is and that we are in an arena to persuade. This isn't science. Thank you.

(Applause.)

FRED BOELTER: Thank you. Do any of the panelists wish to comment?

ALLEN ROGERS: Allen Rogers from Australia --

FRED BOELTER: Excuse me just one minute. Just a minute. Dr. Fowler is going to have a comment, thank you.

DOUG FOWLER: Dr. Corn's comments are similar to those that I have made in court under oath on occasion in that there is always grave uncertainty about attribution of exposure of individuals 40 or 50 years ago when the only information about that